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Remarks on Systems Analysis for Social Problems

by

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Prefatory Note

This paper is based on material presented by the author at a symposium, "Systems Analysis for Social Problems," sponsored by the Washington Operations Research Council; Office of Science and Technology, Executive Office of the President; National Bureau of Standards; The Urban Institute; and Cost Effectiveness Section, Operations Research Society of America. The symposium was held at the National Bureau of Standards in Gaithersburg, Maryland, May 1969.

Session III of the symposium was entitled "Human Resources Development." Speakers and their topics were: Dr. Leonard Lecht, "The Manpower System and National Goals;" Dr. Fred T. Wilhelms, "Educational Systems Problems in Need of Solution;" Stephen Centner, "Systems Analysis and Higher Education Planning;" Prof. Roger Sisson, "System Analysis for School District Decision Making."

The author of this paper was a discussant for Session III. Dr. William Dorfman, U.S. Office of Education was Chairman of the Session, and Mr. Michael Garn of The Urban Institute, Washington, was also a discussant.

Proceedings of the symposium will be published by the Washington Operations Research Council in June 1970.

REMARKS ON SYSTEMS ANALYSIS FOR SOCIAL PROBLEMS

Eugene A. Cogan

It is very clear from the formal presentations that systems analysis in social and educational applications differs from applications in defense and industry. The reason for the differences is equally clear: We have barely begun to apply the techniques of systems analysis in the new contexts of social and educational problems and need a great deal more experience to do it effectively.

Since the papers in this session are quite disparate in subject matter, I shall make no attempt to summarize their content; Instead, I shall direct my remarks to general methodological themes that appear to be common to the four presentations. In this attempt, I will at times echo ideas presented by the speakers and at other times try to point up methodological problem areas illustrated by the presentations.

There are two overriding messages that come through in the four presentations. First, in one way or another, the speakers seem to have disclaimed measuring, defining, or pinpointing benefits and effectiveness, Mr. Centner[1] specifically substitutes "providing information." The speakers have indicated that measures of benefit are important but are beyond the scope of what can be done at this time. However, not taking formal account of the benefit side of a cost-benefit equation is very serious, since costs without benefits is not systems analysis and may, in fact, invite decision-makers to ignore benefit and effectiveness.

The second message that comes through concerns the nature of the algorithms used. These, essentially, project approximate continuation of present means and tend to ignore new ways to bring major innovation into society. Projections of manpower requirements by Dr. Lecht[2] are based on present means of performing construction, health, and education activities. We learned from Dr. Sisson[3] that classrooms should have 80 square feet per student rather than 33, and that there are certain teacher-student ratios in a particular school system. But major innovations in construction and health care can change the relevance of the projection algorithm markedly; Retaining conventional concepts such as "classroom" and "teacher" constrain consideration of the possibilities for major innovations. A computer-administered instructional system, for example, would not involve traditional classroom space. Student

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[1]Stephen Centner, University of Toronto, Toronto, Canada; "Systems Analysis and Higher Education Planning."

[2]Dr. Leonard Lecht, National Planning Association, Washington; "The Manpower System and National Goals."

[3]Professor Roger Sisson, University of Pennsylvania, Philadelphia; "Systems Analysis for School District Decision Making."

space (in the form of instructional stations) would not fit a framework of use during the normal school day. Further, a computer-administered instructional system would be operated by personnel such as instructional programers and subject matter specialists—not "teachers" as we know that concept.

The four papers presented at this session, as well as those presented earlier, suggest there are three major directions for special methodological attention by operations researchers, as well as particular strategic directions to follow to establish a systems approach for educational and social problems. The methodological problems deal with objectives-evaluation-criteria, models-data, and techniques-personnel.

Objectives-Evaluation-Criteria. Carefully defined system objectives (or output) are the first step and the main essentials for a systems analysis. Clear and specific definition of objectives pinpoints the mission and the output so that the functions can be arranged into an operating pattern to produce exactly what the system is supposed to produce. Clear objectives also provide the basis for evaluating alternate systems. They can be used to generate the system output criteria to be measured in terms of cost and benefit. For education and other problems of society, as for any other realm of systems activity, effective analysis, innovation, and design must begin with objectives.

A great deal has been written in the social and educational literature about objectives. Special national commissions have been formed to formulate the purposes, missions, and objectives of education and other social institutions. But the definitions available are either very general, so fuzzy as to be worthless for analysis or design, or very narrow and lacking authentication. For example, education is a key instrument of society to serve both long-term and relatively unchanging purposes, and it also is an instrument for use in coping with immediate societal problems. Clearly, among the missions of education are occupational preparation, influence on attitudes and values, teaching basic skills and knowledges, helping people to "get more out of life," and so on. All of these seem valid and appropriate as objectives, but a systems analyst or systems desinger needs much more specific, detailed, and complex specifications for his work.

The most useful and important single step to further improvement in education and other social mechanisms would be an authoritative system of objectives, carefully prepared, in clear, specific, and measurable terms and with indices of relative importance. As Dr. Wilhelms[1] points out in his paper, educational objectives in common use are input rather than output and, hence, not objectives at all. HumRRO's work on computer-administered instruction, our Project IMPACT,[2] includes an aspect that specifically bears on Dr. Wilhelms' comments about typical

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[1]Dr. Fred T. Wilhelms, National Education Association, Washington; "Educational Systems Problems in Need of Solution."

[2]Robert J. Seidel and the IMPACT Staff, *Project IMPACT: Computer-Administered Instruction Concepts and Initial Development*, HumRRO Technical Report 69-3, March 1969.

educational "non-output" objectives. Working with a computer as the major instrument for processing and administering instructional elements helps force one to give direct attention to "output" variables in the form of the real world capabilities the student should have upon completion of a course and, in addition, forces careful attention to relating the bits of instruction to output characteristics. In HumRRO, we have found the term "terminal objectives" to be useful in referring to output-real world capabilities, and "enabling objectives" to refer to input-mediating instructional elements.

The kinds of instruction programs HumRRO has been working with can be accurately referred to as "systems analytic *training* programs." For example, our work with computer-administered instruction is currently dealing with the training of computer programmers. The first step in developing the instructional program involved a survey of the jobs graduates of the course would go to. As part of the survey, we identified exactly what the programmers were expected to do when they arrived on the job. From the descriptions, we prepared an inventory of the activities or tasks that were to serve as "output" or terminal behavioral objectives for the course. These objectives, in turn, were subjected to analysis into the mediating or enabling objectives consisting of skills and knowledges, and each of these was selected for inclusion in instruction in terms of status as needed steps in executing tasks defined in terminal objectives.

To the extent that our analysis has been astute, we have definable and measurable output characteristics, and a meaningful set of "production processes" for these outputs. A systems analysis approach with emphasis on real world output specifications provides the means to break away from "one fact after another" and replace it with input-output concepts.

Models-Data. The chief instrument of systems analysts consists of a model of the phenomena being dealt with and of the functions ("production processes") that must be performed in order to achieve a desired output. Models are mathematical or quasi-mathematical representations of the process and of the orderly relationships between things at a beginning state, operations performed with these things, and the consequences as output characteristics. In order for useful models to be devised, there must be a firm foundation of good and plentiful data from which models can be devised and tested.

Despite the fact that much research has gone on in the psychology of learning and in the sociology of social problems, and that educational and social research data have accumulated in the literature over centuries, very little is really known and understood about the instructional process as it takes place in educational institutions or about behavior as it occurs in society. The theories (i.e., models) and data that exist, fall far short of the robustness and breadth needed for effective systems analysis and design.

For education, there is a very long tradition of developing data. The Office of Education has long collected, analyzed, and published educational statistics. However, these statistics have mainly concerned

administrative rather than instruction process-oriented matters, and for that reason have been only partially useful in devising the models needed.

Two recent large-scale efforts to develop more and better data for understanding education are available to the research community. The first is the data bank produced in Project Talent, an activity of the American Institutes for Research and sponsored by the Office of Education and the Department of Defense.[1]

Another data bank, more recent than Project Talent, is that developed for the so-called "Coleman Study" on equality of educational opportunity.[2] This effort, drawing upon the experiences of Project Talent and further developments in thinking about education since the inception of Project Talent, was mainly oriented to the civil rights aspects of education. At the same time, it provides an excellent general-purpose data bank on the entire country and contains information on more than a half million students at the public school level. The equality of educational opportunity bank is also being explored in a vigorous fashion toward a better understanding of factors important in educational achievement. A third data bank, soon to become available, will be that compiled in the National Assessment of Educational Progress. This project is gathering—and will make available to educators and the public alike—the first census-like data on the educational attainments of young Americans (what they know and can do). It will also measure what growth takes place in selected aspects of those attainments over a period of time (providing indices which show the actual progress in education, or lack thereof). There is also much interest in establishing country-wide data in the form of social indicators. These would provide a very useful data bank, for a variety of social problems, but it doesn't exist as yet.

Techniques-Personnel. The framework of society and education differs from that of the Department of Defense or an industrial setting, because, although education and other social functions are very large activities, they are managed in the form of a great many relatively small, independent and heterogeneous units. Also, the nature of the "soft" phenomena of education and social factors makes direct application of "hard" experience of system analysts and systems design people not quite right. These factors have an important bearing both on the kinds of techniques that are needed for systems analysis and the kinds of people who can perform effectively in that role.

There is a clear need to broaden and generalize traditional systems analysis decision paradigms to accommodate the organization (or unorganization) existing in society. Where unitary, hierarchical management exists, many variables that are relevant to a decision can be set

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[1]John C. Flanagan, *et al. Project TALENT, Studies of the American High School*, University of Pittsburgh, Pittsburgh, Pennsylvania, 1962.

[2]James S. Coleman, *et al. Equality of Educational Opportunity*, U.S. Department of Health, Education, and Welfare, OE-38001, U.S. Government Printing Office, Washington, 1966.

as fixed values, by applying "readings" from the operating context of the decision-maker. For education and other social problems, this won't do because there are tens of thousands of decision-makers, each of whom needs a basis for making his own choice among alternative courses of action. Hence, considerable and important developmental work is needed to develop formal and general decision paradigms. These are needed to aid the decision-maker in identifying and measuring the critical variables to be specified in order to tailor the decision to his conditions and constraints.

A decade or so ago, the systems approach was typically characterized as the inter-disciplinary approach to problems, and teams of different kinds of specialists were assembled to approach problems. The inter-disciplinary aspects, perhaps as a consequence of increasing subject matter sophistication on the part of systems analysts, has recently received much less emphasis. However, it is worthwhile to think of education today in terms of the Department of Defense and industry of a couple of decades ago. We should reinstitute the concept of the inter-disciplinary team for exactly the reasons it was so useful in the early days of industrial and defense systems analysis. Only rare individuals combine the experience, knowledge, and technique sophistication needed for useful and important work in education. Teams for education should certainly consist of systems analysts, computer specialists, experienced teachers, education administrators, and educational researchers. Occupation specialists and manpower people should probably also be on the team. From this team work, if it is truly innovation, should come (a) new concepts to replace notions such as "teacher" with more diversified and specialized personnel to perform functions needed in new systems, (b) concepts substituting for "classroom," and (c) ideas we can barely imagine.

Strategies for Action. For education, we need to do something to get away from instruction prepared for presentation to groups. Individuals are malleable to at least some degree in IQ, in attitude, in motivation, and in temperament. At the same time, individuals differ massively in terms of background and other characteristics of all sorts.

The single most promising direction for massive improvement in education consists of individualizing instruction in order to match instruction to the characteristics of the student. Obviously, such individualization cannot be done when a teacher or other instructional agent provides a given standard set of materials to a group of 30-50 students. It requires applying modern technology and technology not yet developed. For the best student, the benefits of individualization are probably not very visible because he will learn adequately, regardless of method of instruction—perhaps learning as much or more at home or in the library as in school. But with a system encompassing individualized tailoring of instruction, the best student can learn much more per unit of time than with traditional techniques. For the poor student, the effects are more visible, and from society's viewpoint may be much more important. Matching instruction to the poor student's characteristics can make the difference between a learning system and a quasi-incarceration system to keep him off the streets until he is 16 years

old. A truly massive payoff for improving education can come only with the introduction of well conceived individualized instruction.

Emphasis on fundamentals for systems analysis or innovation should not be at the expense of actually going about innovating and designing systems. It is only through the moving inertia of ongoing and new projects that big solutions can develop. Attention must be paid to designing systems for use and for the user. It is traditional to speak about hardened resistance to innovation in the educational community and to point to lags of 50 years between an educational innovation and its diffusion to users. It may be more to the point to criticize the systems innovators for failing to complete development work by producing total package systems that can be adopted readily. Defense Department concepts of total system development and procurement—which include not only the hardware but training programs, spare parts, maintenance procedures and aids, training devices and so on—provide a model that could and should be adopted by educational and social innovators. It is not efficient for many people throughout the country to be wondering "How do you get this kind of thing going? What other things will we need to go with it? What does my staff need to learn in order to use it? How can I train them?"

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13. ABSTRACT

In this paper the need for more experience in *how* to adapt and apply the techniques of systems analysis to social and educational problems is stressed. Education and other social institutions, although very large activities, are managed as small independent units; therefore, adapting techniques from other applications and to form *general* decisions paradigms is mandatory. As for any systems analysis, it is necessary to begin with specific, carefully defined output objectives. For example, rather than subject matter approaches to educational curricula, output (desired resulting performance competence) should be used to identify input (instructional content). Use of system analysis techniques is essential to develop ways to solve social problems. For education, individualizing instruction to vastly improve the education process requires a systems analysis approach.

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